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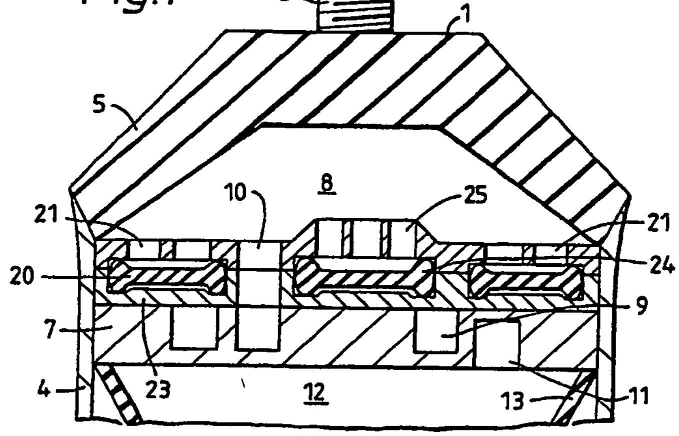
(54) Hydraulically damped mounting device

(57) A hydraulically damped mounting device has a first anchor point (1) connected to a second anchor point (4) by a resilient wall (5). A partition (7) is fixed to the second anchor part (4) and defines, together with the resilient wall (5), a working chamber (8) for hydraulic fluid. The working chamber (8) is connected by a passageway (9) to a flexible wall (13). First and second diaphragm parts (20, 24) are mounted on the partition (7) and gas pocket(s) are defined between the diaphragm parts (20, 24) and the partitions. The gas pocket(s) may have a valved bleed orifice (61, 62, 64, 65) (Fig. 9, not shown) extending therefrom. The two diaphragm parts (20, 24) have different characteristics. They may have different stiffnesses, or different effective stiffnesses, the latter being affected by the shape of openings (21) in the snubbers associated with the diaphragm parts (20, 24) and/or by the valved bleed orifices. One or both of the diaphragm parts (20, 24) may be convoluted, preferably with associated convoluted snubber surfaces.

Fig.1



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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Fig.1

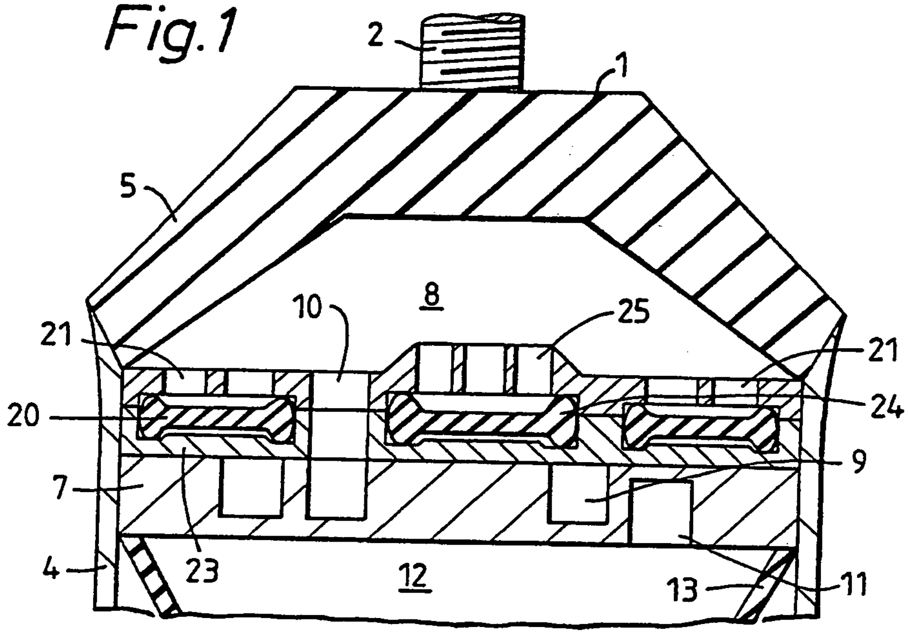


Fig.2

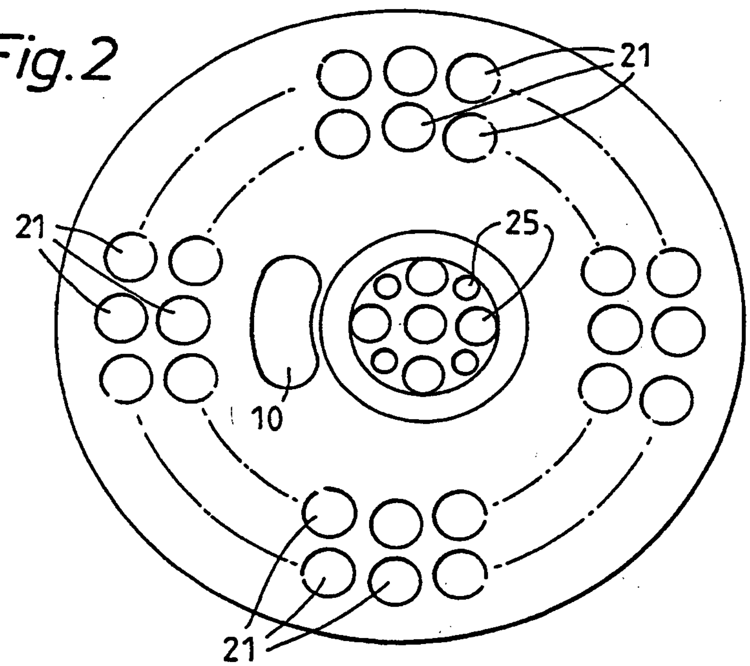


Fig.3

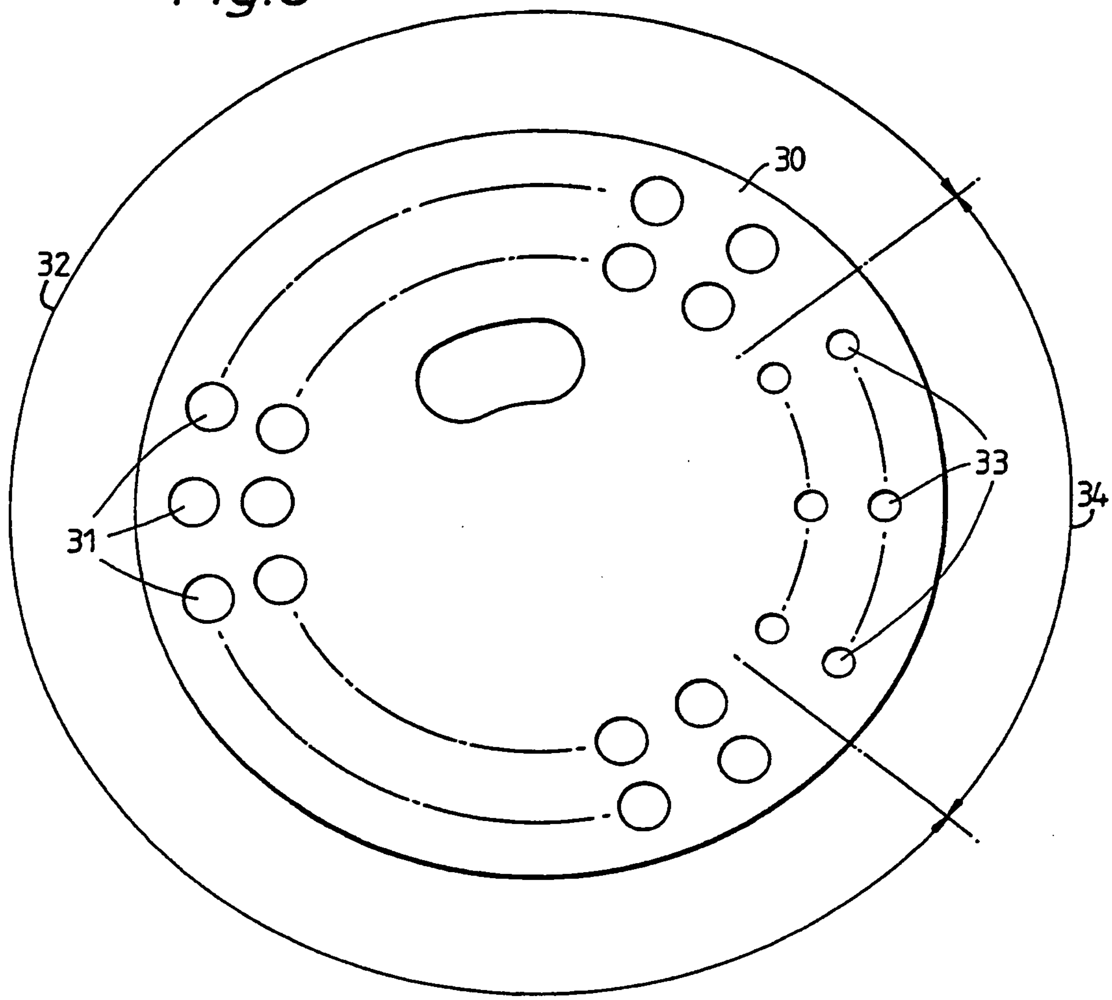


Fig.4

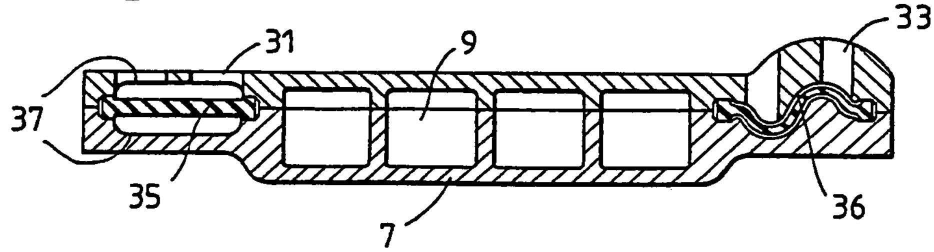


Fig.5

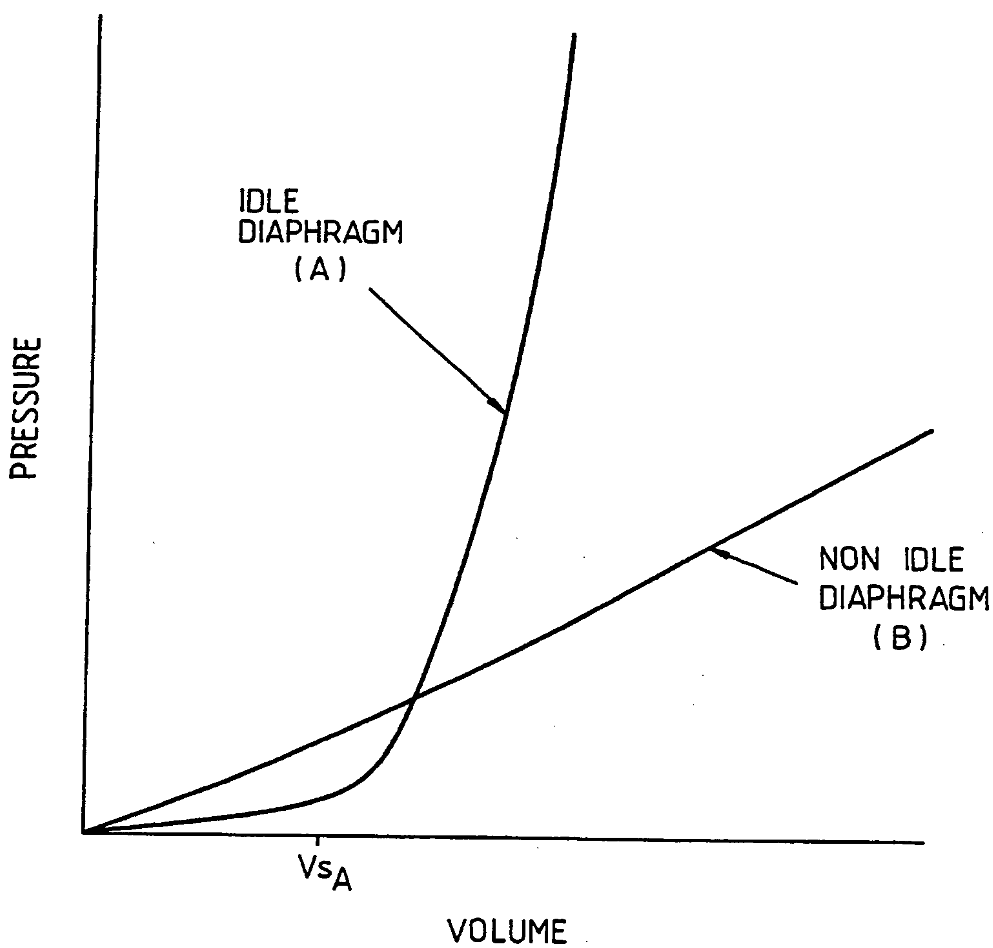


Fig.6

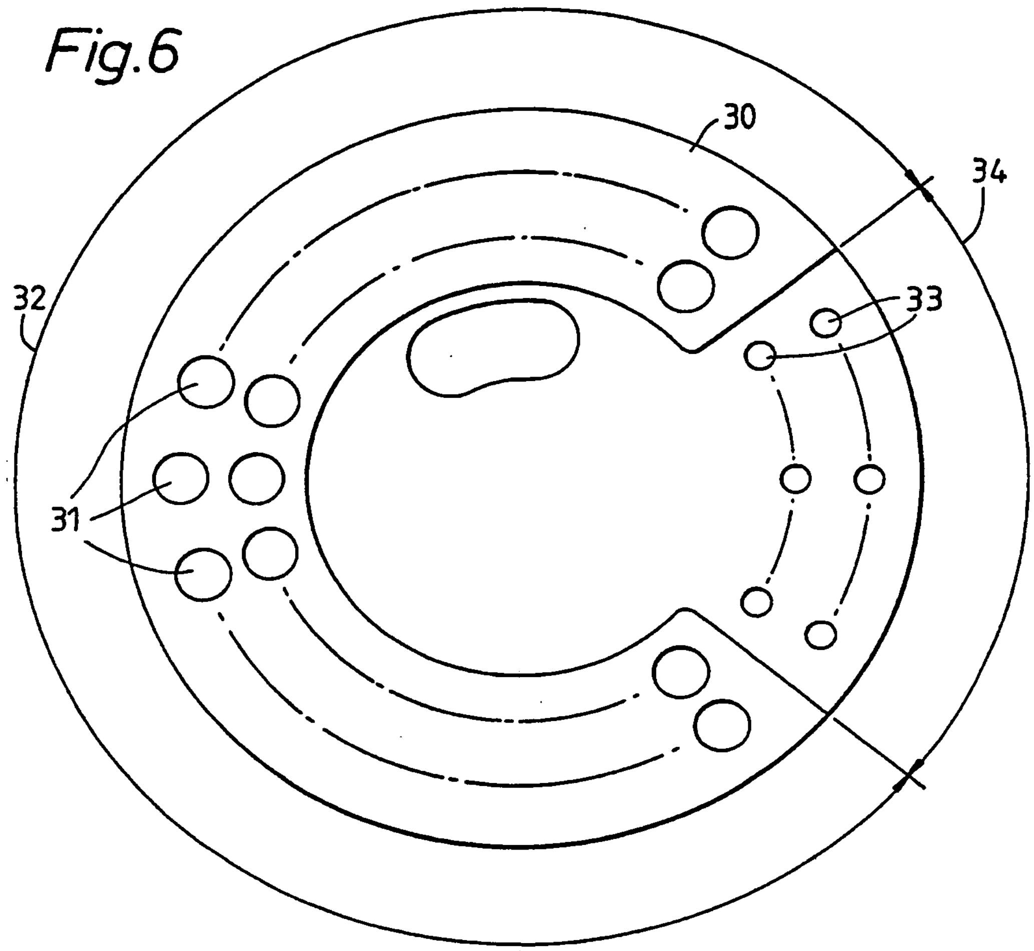


Fig.7

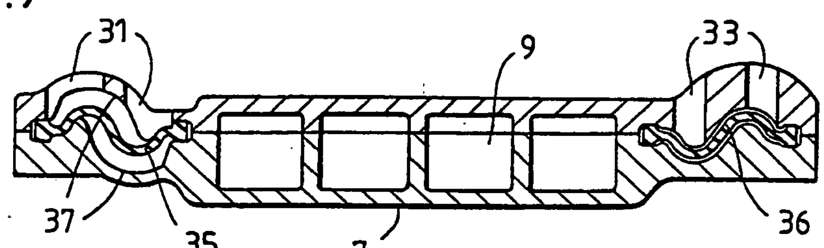


Fig. 8

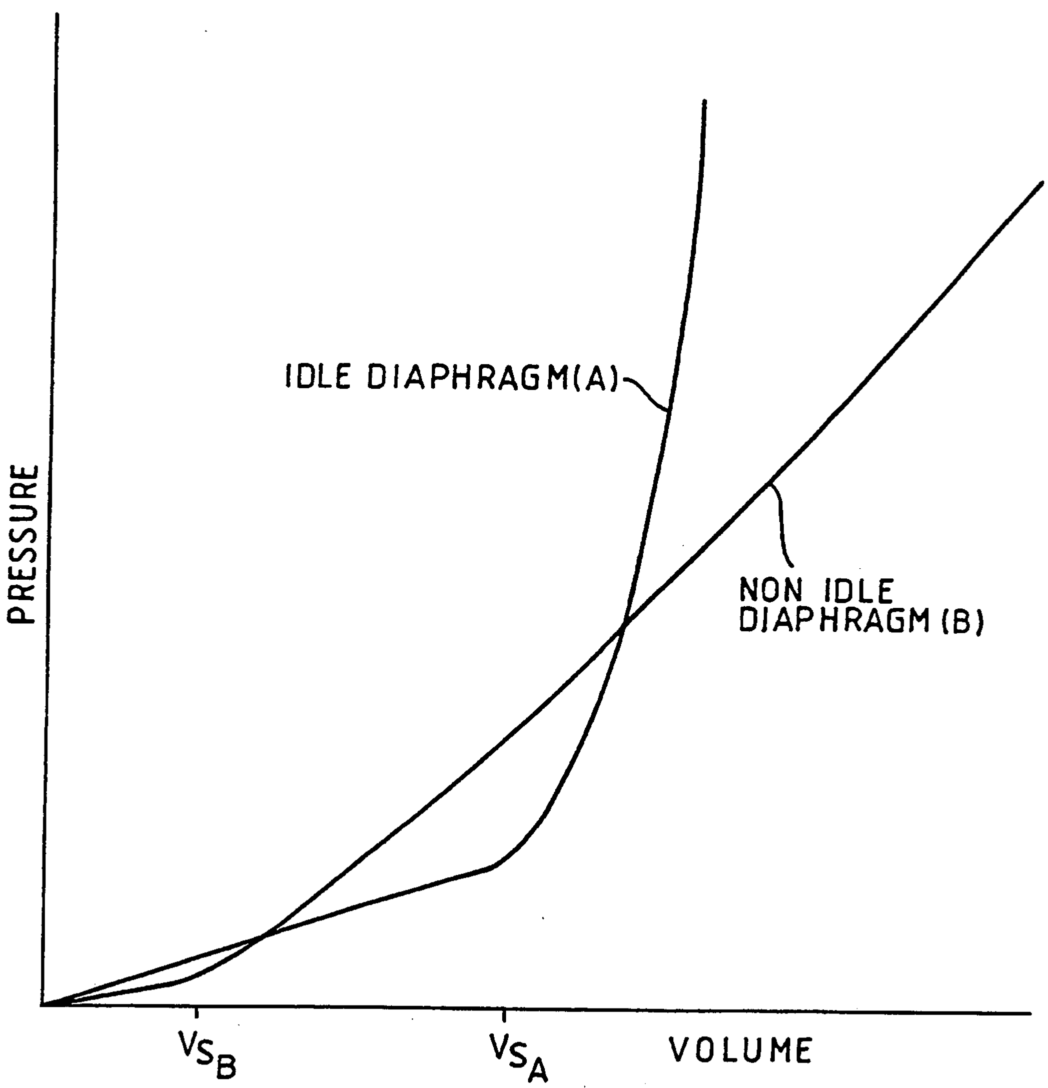

IDLE DIAPHRAGM (A)
PRESSURE
NON IDLE
DIAPHRAGM (B)
V_{S_B}
V_{S_A}
VOLUME

Fig.9

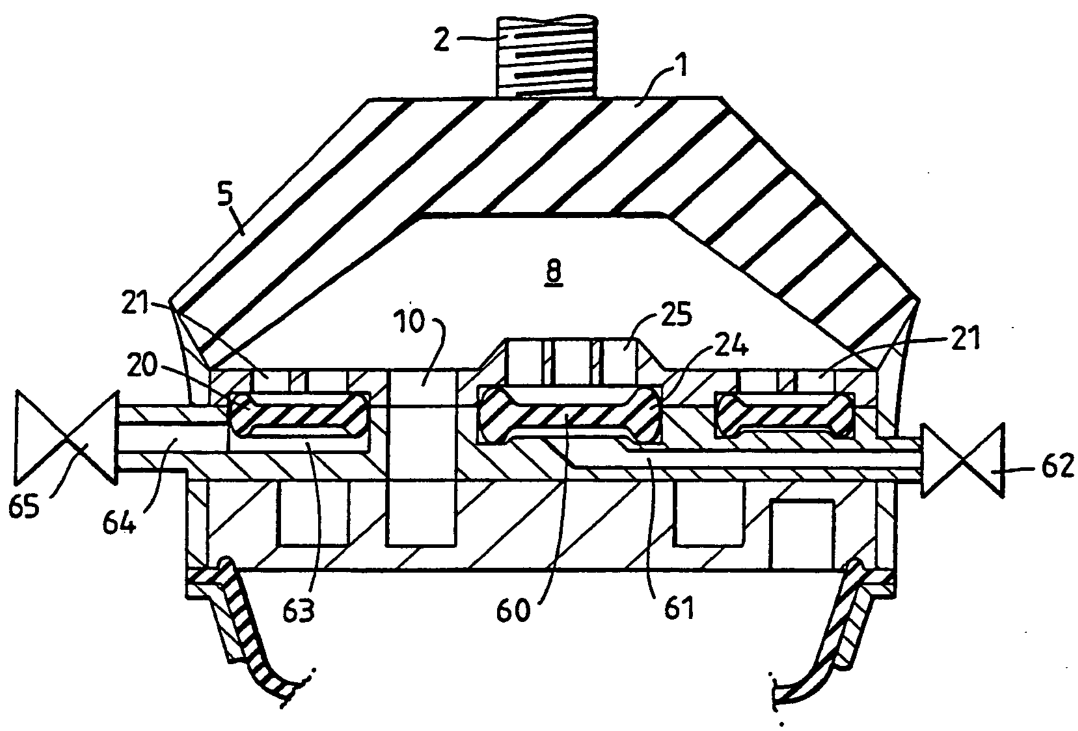


Fig. 10

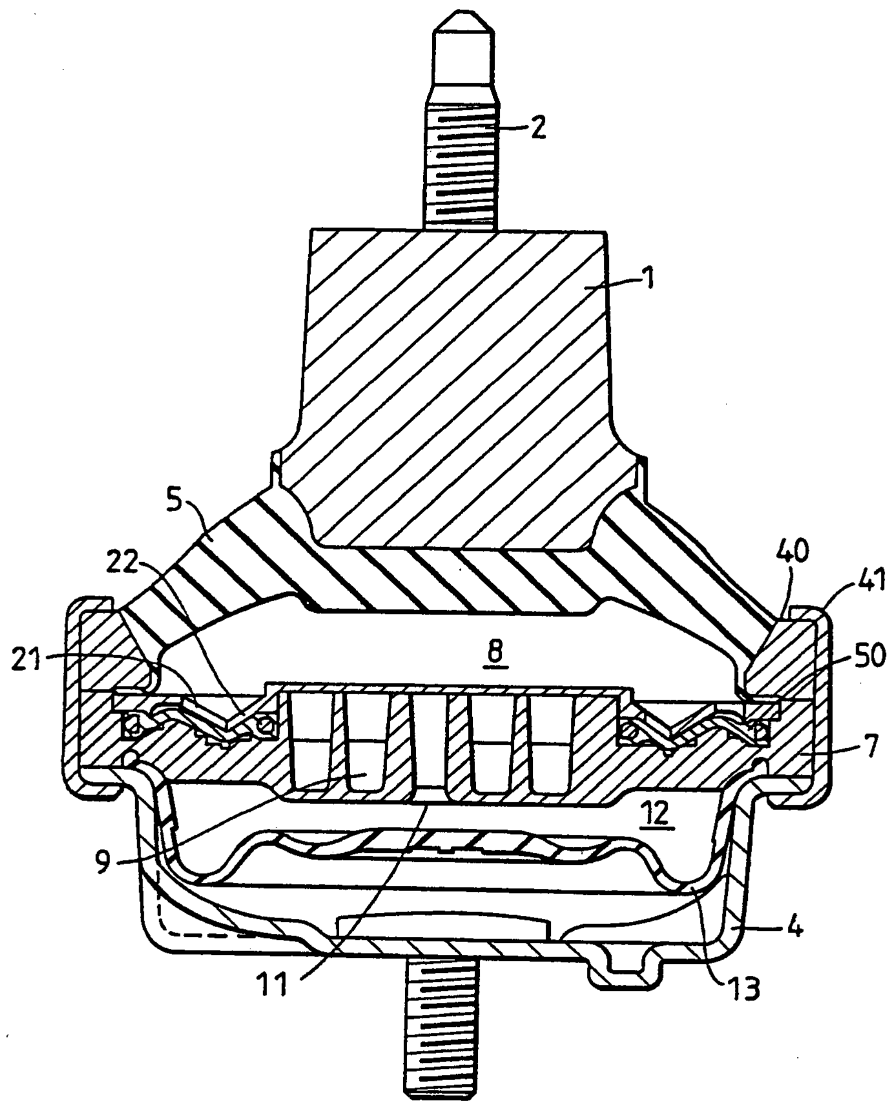


Fig.11

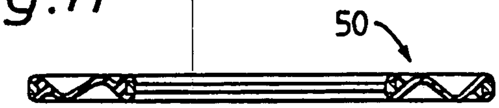


Fig.12

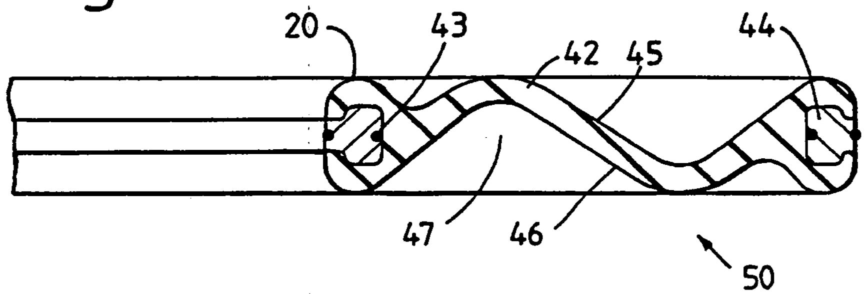
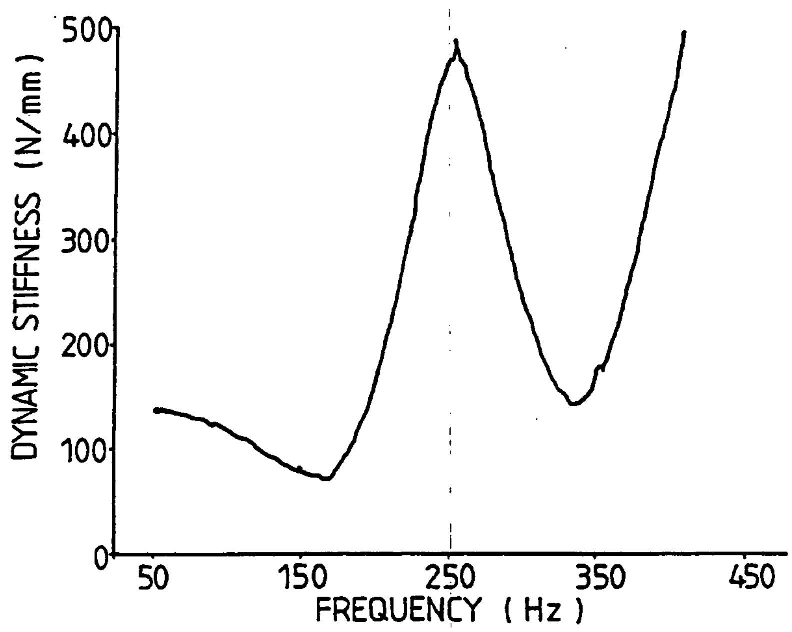


Fig.13



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HYDRAULICALLY DAMPED MOUNTING DEVICE

The present invention relates to a hydraulically damped mounting device. Such a device usually has a pair of chambers for hydraulic fluid, connected by suitable passageway, and damping is achieved due to the flow of fluid through that passageway.

EP-A-0115417 and EP-A-0172700 discussed two different types of hydraulically damped mounting devices for damping vibration between two parts of a piece of machinery, e.g. a car engine and a chassis. EP-A-0115417 disclosed various "cup and boss" type of mounting devices, in which a "boss", forming one anchor part to which one of the pieces of machinery was connected, was itself connected via a deformable (normally resilient) wall to the mouth of a "cup", which was attached to the other piece of machinery and formed another anchor part. The cup and the resilient wall then defined a working chamber for hydraulic fluid, which was connected to a compensation chamber by a passageway (usually elongate) which provided the damping orifice. The compensation chamber was separated from the working chamber by a rigid partition, and a flexible diaphragm was in direct contact with the liquid and, together with the partition formed a gas pocket.

In EP-A-0172700 the mounting devices disclosed were of the "bush" type. In this type of mounting device, the anchor part for one part of the

vibrating machinery is in the form of a hollow sleeve with the other anchor part in the form of a rod or tube extending approximately centrally and coaxially of the sleeve. In EP-A-0172700 the tubular anchor part was connected to the sleeve by resilient walls, which defined one of the chambers in the sleeve. The chamber was connected via a passageway to a second chamber bounded at least in part by a bellows wall which was effectively freely deformable so that it could compensate for fluid movement through the passageway without itself resisting that fluid movement.

In the hydraulically damped mounting devices disclosed in the specifications discussed above, there was a single passageway. It is also known, from other hydraulically damped mounting devices, to provide a plurality of independent passageways linking the chambers for hydraulic fluid.

In EP-A-0115417, there was a single diaphragm, which was configured to give a specific influence on the vibration characteristics of the hydraulically damped mounting device. Those characteristics depended on the stiffness of the diaphragm, by which is meant the change in applied pressure needed to cause unit change in the volume displaced by the diaphragm. Furthermore, the surface of the diaphragm which is in contact with the fluid in the working chamber must be covered by a snubber plate,

with openings therein for fluid communication therethrough between the upper surface of the diaphragm and the rest of the working chamber, and it has been found that the size of those openings also affects the characteristics of the mount.

A first aspect of the present invention therefore proposes that the hydraulically damped mounting device be provided in which there are two diaphragm parts with different characteristics. Preferably, the two diaphragm parts have different effective stiffnesses. Alternatively, or in addition, one diaphragm part is of a first stiffness and is covered by a snubber plate with an opening or openings therein which have a first ratio of the sum of the areas of those apertures to their average length, and the second diaphragm part has a second stiffness different from the first, and is covered by a snubber plate with an opening or openings for which the ratio of the sum of the areas to the average length has a second ratio which is different from the first ratio.

One way of providing different effective stiffnesses is to make use of valved bleed orifices, leading from the gas pocket(s) associated with the two diaphragm parts, in a similar way to that disclosed in EP-A-0262544. In such an arrangement, the effective stiffness of the two diaphragm parts is determined by the diaphragm parts themselves, but

also by the control of the valve of each bleed orifice, that control affecting the resistance of gas movement to or from the gas pocket associated with the diaphragm parts. It can be noted that it is possible for each diaphragm part to have a corresponding gas pocket, so that there are two valve bleed orifices. In that case, the valves may be controlled independently or in unison.

In this way, the two diaphragm parts can be adjusted to avoid an undesirable effect of standard hydraulically damped mounting device of e.g. EP-A-0115417. Normally, such hydraulically damped mounting devices are arranged to provide high levels of damping for vibration frequencies of the 8 to 11 Hz range. When used as a mounting device for an engine, it is also desirable, in order to avoid shake when the engine is idling, for the hydraulically damped mounting devices to have low dynamic stiffness for vibration frequencies in the 20 to 25 Hz region. In the hydraulically damped mounting device of e.g. EP-A-0115417 these are conflicting interests, since any attempt to reduce the dynamic stiffness in the 20 to 25 Hz region necessarily reduces damping levels in the 8 to 11 Hz region. With the first aspect of the present invention, however, it is possible to create a low dynamic stiffness at e.g. 20 to 25 Hz by providing a suitably tuned anti-resonance in the mount. This

can be achieved by a suitable selection of the characteristics of the two diaphragm parts discussed above. However, the present invention is not specifically limited to these frequency characteristics, since it is possible to give different characteristics by suitable determination of the parameters discussed above.

It should be noted that EP-A-0164081 discloses a hydraulically damped mounting device in which there are two (separate) partition regions. However, the stiffnesses of those regions is not disclosed, and there are no covering snubber plates.

In the present invention, the first and second diaphragm parts may be separate or integral. The latter case has the advantage of ease of manufacture. For example, if an annular diaphragm is used, one diaphragm part may be formed over part of the circumference of that annulus and the other diaphragm part be formed over the rest of the circumference.

Alternatively, or in addition, one diaphragm part is of a first stiffness and is covered by a snubber plate with an opening or openings therein which have a first ratio of the sum of the areas of those apertures to their average length, and the second diaphragm part has a second stiffness different from the first, and is covered by a snubber plate with an opening or openings for which

the ratio of the sum of the areas to the average length has a second ratio which is different from the first ratio.

The diaphragm part which has the lesser stiffness is preferably the one for which the opening(s) in the covering snubber plate have the smaller ratio of area sum to average length.

For displacements of the diaphragm parts greater than predetermined amounts, one or both of the diaphragm parts will contact the snubbing surfaces thereof and this will change the effective stiffness (as distinct from the intrinsic stiffness of the diaphragm material discussed above). As the snubbing effect increases, the effective stiffness will increase rapidly.

In a further development of the present invention, it is preferable that the two diaphragm parts contact the snubbing surfaces at different points in the pressure/displacement volume characteristic of the respective diaphragm part, e.g. by providing different spacings of the surfaces. Thus, in the case discussed above where the less stiff diaphragm part has the larger ratio of opening area sum to average length, that diaphragm part is then arranged to snub at a smaller displacement volume than the other diaphragm part.

However, the snubbing effect also permits a more complex arrangement to be achieved, by suitable

design of the snubbing surfaces. In such an arrangement, one diaphragm part has a lower stiffness and a higher ratio of opening area sum to average length. That diaphragm part is then arranged to snub at a lower displacement volume, but for that snubbing to be gradual so that it is not complete until displacement volumes greater than the displacement volume at onset of snubbing of the other diaphragm part.

One way of achieving such gradual snubbing is to use a convoluted diaphragm, together with corresponding curved snubbing surfaces. It has also been found that such a convoluted diaphragm may permit a further advantage to be achieved, namely to enhance an anti-resonance (i.e. low dynamic stiffness) which peaks at a particular frequency, without significantly reducing the mean dynamic stiffness over a wider frequency range including the particular frequency of the anti-resonance. For an engine mount, the enhanced anti-resonance may be of the order of 150 Hz to 175 Hz. The enhancement of such an anti-resonance may be of benefit in some vibration situations.

Therefore, according to a second aspect of the present invention, an annular diaphragm is provided on the partition between the working and compensation chambers, which contacts the hydraulic fluid in the working chamber and which is

convoluted. Such convolutions may involve:

a) a diaphragm where one or both surfaces of the diaphragm cross the line joining the radial edges thereof at least twice; and/or

b) an annular diaphragm in which the actual surface area of the diaphragm which is contacted by hydraulic fluid exceeds the area of the annular plane defined between the radial edges of the part contacted by hydraulic fluid by a factor of at least 1.1, preferably higher.

With such a convoluted annular diaphragm, it is also desirable that the diaphragm is relatively thin in proportion to its radial width (between the edges of the annules), with the ratio of the minimum thickness to the radial width being not greater than 1/8.

Although such a convoluted diaphragm may be used in the first aspect of the present invention, the use of a convoluted annular diaphragm represents a second, independent, aspect of the present invention.

Preferably, curved snubbing surfaces are provided adjacent the diaphragm to limit the movement thereof during vibrations of the mounting device. The upper snubbing surface will then have openings therein to permit hydraulic fluid in the working chamber to communicate with a surface of the diaphragm. The other snubbing surface may be the

surface of the partition which, together with the diaphragm, defines the gas pocket. Alternatively, it may be a surface within the gas pocket with openings therein. The snubbing surfaces preferably conform to the shape of the convolutions of the diaphragm.

Embodiments of the present invention will now be described in detail, by way of example, with reference to the accompanying drawings in which:

Fig. 1 is a sectional view through part of a first embodiment of the present invention;

Fig. 2 is a plan view of the snubber plate in the embodiment of Fig. 1;

Fig. 3 is a plan view of the snubber plate for use in a second embodiment of the present invention;

Fig. 4 is a sectional view through the partition of the second embodiment;

Fig. 5 is a graph of the pressure/volume characteristic of the second embodiment;

Fig. 6 is a plan view of a snubber plate for use in a third embodiment of the present invention;

Fig. 7 is a sectional view through the partition of the third embodiment;

Fig. 8 is a graph of the pressure/volume characteristic of the third embodiment;

Fig. 9 is a cross-sectional view through a fourth embodiment of the present invention;

Fig. 10 is a cross-sectional view through a

fifth embodiment of the present invention;

Fig. 11 is a sectional view through the diaphragm used in the fifth embodiment;

Fig. 12 is a detailed view of part of the diaphragm of Fig. 11; and

Fig. 13 is a graph of the stiffness/frequency characteristic of the fifth embodiment.

Referring first to Fig. 1, a first embodiment of a hydraulically damped mounting device according to the present invention is shown for damping vibration between two parts of a structure (not shown). The mount has a boss 1 connected via a fixing bolt 2 to one of the parts of the structure, and the other part of the structure is connected to a generally U-shaped cup 4. A resilient spring 5 of e.g. rubber interconnects the boss 1 and the cup 4. A partition 7 is also attached to the cup 4 adjacent the ring 6, and extends across the mouth of the cup 4. Thus, a working chamber 8 is defined within the mount, bounded by the resilient spring 5 and the partition 7.

The interior of the partition 7 defines a convoluted passageway 9 which is connected to the working chamber 8 via an opening 10 and is also connected via an opening 11 to a compensation chamber 12. Thus, when the boss 1 vibrates relative to the cup 4 (in the vertical direction in Fig. 1), the volume of the working chamber 8 will change, and

hydraulic fluid in that working chamber 8 will be forced through the passageway 9 into, or out of, the compensation chamber 12. This fluid movement causes damping. The volume of the compensation chamber 12 needs to change in response to such fluid movement, and therefore the compensation chamber 12 is bounded by a flexible wall 13.

The above structure is generally similar to that described in EP-A-0115417, and the manner of operation is similar. In EP-A-0115417, the partition supported a diaphragm which acted as a boundary between fluid in the working chamber and a gas pocket. In the embodiment of Fig. 1, there is a first diaphragm part 20 which is annular. One side of that first diaphragm part 20 communicates with the working chamber 8 via openings 21 in a snubber plate 22 secured to the partition 7, and the other side of which bounds a gas pocket.

In the embodiment of Fig. 1, there is also a lower snubber plate 23 secured to the partition, although that snubber plate 23 may be integral with the rest of the partition 7. Thus, when the boss 1 vibrates relative to the cup 4, hydraulic fluid will move through the opening 21 causing movement of the first diaphragm 20 between the snubber plates 21,23.

In the embodiment of Fig. 1, there is a second diaphragm part 24, which is generally circular. One

side of that second diaphragm part 24 communicates with the working chamber 8 via opening 25, in the snubber plate 22, and the other side bounds a further gas pocket. Hence, the second diaphragm part 24 will move between the snubber parts 21,23 as hydraulic fluid moves through the opening 25 due to the vibration of the boss 1 relative to cup 4.

It can be seen from Figs. 1 and 2 that the size and length of the openings 21,25 differ. Thus, it is possible to define opening ratios for the diaphragm parts 20,24 as follows:

$$R_{20} = \frac{\text{sum of areas of openings 21}}{\text{average length of openings 21}}$$

$$R_{24} = \frac{\text{sum of area of openings 25}}{\text{average length of openings 25}}$$

Furthermore, dependent on the material, thickness, etc. of the diaphragm parts 20,24, they will have stiffnesses S_{20}, S_{24}. The stiffness of the diaphragm parts 20,24 is defined as the change in applied pressure needed to cause unit change in displaced volume of the corresponding diaphragm. As was previously mentioned, the present invention permits an anti-resonance to be created to eliminate idle shake when used as an engine mounting. Therefore, in the subsequent discussion the second diaphragm part 24 will be referred to as the idle diaphragm since it is normally this diaphragm part whose characteristics are determined to eliminate idle shake as discussed above.

In a preferred arrangement within the present invention, the idle diaphragm has a lesser stiffness and a lower ratio of opening area sum to average length. Thus, $S_{24} < S_{20}$ and $R_{24} < R_{20}$. However, other alternatives are also possible within the present invention.

In the first embodiment described above, the first and second diaphragm parts 20,24 are separate. However, they may be integral as will now be described.

Figs. 3 and 4 illustrate a second embodiment of the present invention, in which there is an annular diaphragm which is thus similar to the diaphragm 20 in Fig. 1. Fig. 3 illustrates the shape of the snubber plate 30 of this embodiment, which replaces the snubber plate 21. It can be seen that there are a first group of openings 31 in that snubber plate extending over a first part 32 of the circumference and second openings 33 extending over a second part 34 of the circumference. From Fig. 4, it can be seen that the length of the openings 31 is much less than the length of the opening 33. The two parts of the diaphragm 33 have different stiffnesses e.g. by having different thicknesses. Therefore, the diaphragm 35 then has different characteristics over the regions 32,34 respectively, so that the region 34 forms an idle diaphragm section and region 32 corresponds to the standard diaphragm. In the

region 34 the diaphragm is convoluted and the snubbing surfaces are curved to conform to those convolutions.

Preferably, for vibration frequencies in the range 8 to 30Hz the volume displaced by the idle diaphragm section is less than that of the standard diaphragm section for mount displacement amplitudes greater than approximately ± 0.4 mm. Hence, as can be seen from Fig. 4, the shape of the snubbing surfaces of the partition 7 and the snubber plate 30 are different for the idle diaphragm section and the standard diaphragm section of the diaphragm 35.

The effect of this is shown in Fig. 5. This illustrates the pressure/displacement volume characteristics for the idle diaphragm section (line A) and the standard (non-idle) diaphragm section (line B). As the pressure increases, due to vibration of the mounting device, the lower stiffness of the idle diaphragm causes it to displace a greater volume for unit pressure change. However, at a volume Vs_A, the idle diaphragm begins to interact with its snubbing surface and therefore its effective stiffness increases. If the volume Vs_A corresponds to a displacement slightly less than 0.4mm, it can be seen that for displacements less than that value, the volume displaced by the idle diaphragm is greater than that displaced in the standard diaphragm, whereas for displacements

greater than approximately 0.4 mm, the volume displacement for a given pressure change is less. The 0.4 mm displacement point thus should be made to correspond approximately to the crossing point of points A and B in Fig. 5.

The displacement volume at which snubbing starts to occur, and the pressure/displacement volume characteristic thereafter depends on the geometry of the mount. Thus, by suitable adjustment for both the idle and standard diaphragm regions, other characteristics may be achieved. Figs. 6 and 7 illustrate a third embodiment of the present invention. This embodiment is generally similar to the second embodiment, and the same reference numerals are used to indicate corresponding parts. However, in the second embodiment, the snubbing surfaces 36 of the idle diaphragm section are curved to conform to a convoluted part of the diaphragm, and the snubbing surfaces 37 of the standard diaphragm section are not. In the third embodiment, however, both the snubbing surfaces 36 and 37 are curved to conform to a convoluted diaphragm. Furthermore, the idle diaphragm section is stiffer than the standard diaphragm section.

The effect of this is shown in Fig. 8. As the pressure increases from zero, the displacement of the standard diaphragm section is greater than that of the idle diaphragm section, until the standard

diaphragm section interacts with the snubber surfaces 37 at a volume corresponding to displacement volume Vs_B. The effective stiffness of the standard (non-idle diaphragm) then increases, as shown by curve B in Fig. 8. However, this increase is designed, by shape of the snubber surfaces 37, to permit some movement of the standard diaphragm section. For the idle diaphragm, illustrated by curve A in Fig. 8, however, the initial effective stiffness is greater than that of the standard (non-idle) diaphragm, up to slightly greater than that which cause the standard (non-idle) diaphragm to interact with the snubber surfaces 37. Hence, the curves A and B cross for displacement volumes above Vs_B.

At higher pressures, the idle diaphragm begins to interact with the snubber surfaces 36, corresponding to a displacement volume of Vs_A. The effective stiffness of the idle diaphragm then increases rapidly, so that the curve A re-crosses the curve B at displacement volumes slightly greater than Vs_A.

In such an embodiment it is preferable that:

$$Vs_B < Vs_A < 5\ Vs_B$$

The above embodiments illustrate that a variety of pressure/volume characteristics can be achieved by suitable selection of the stiffnesses of the two diaphragm parts, of the size and length of the

openings which connect the surface of the first and second diaphragm parts to the working chamber, and to the snubbing characteristics. Thus, the gradients of the curve A and B in Figs. 5 and 8 both above and below Vs_A and Vs_B can be adjusted to provide the desired characteristics of the hydraulically damped mounting device.

EP-A-0262544 disclosed a mounting device of the "bush type" similar to that of EP-A-0115417, but in which the gas pocket had a bleed orifice leading therefrom, and there was means of controlling the gas flow in that bleed orifice. This idea can be applied to the present invention, and a fourth embodiment illustrating this is shown in Fig. 9. The embodiment of Fig. 9 is generally similar to the embodiment of Fig. 1, and corresponding parts are indicated by the same reference numerals.

In this fourth embodiment, however, the gas pocket 60 below the second diaphragm part 24 has a bleed orifice 61 leading therefrom, the bleed orifice passing to a valve 62. In a similar way, the gas pocket 63 below the first diaphragm part 20 has a bleed orifice 64 leading to a valve 65. Thus, by controlling the valves 62 and 65, the characteristics of the air springs formed by the diaphragms 20 and 24 and the respective gas pockets 63 and 61 may be controlled e.g. in dependence on the frequency of vibration of the mount, as in EP-A-

In this case, each diaphragm part 20, 24 has an effective stiffness which is determined not only by the material of which the diaphragm part is made, but also by the effect of the respective bleed orifice and valve.

It can further be noted that the valves 62 and 65 may be controlled independently, or in unison, depending on the particular mount characteristics that were required.

A fifth embodiment of the present invention, shown in Fig. 10, uses a convoluted annular diaphragm. The overall structure of the embodiment shown in Fig. 10 (with the exception of the diaphragm) is generally similar to that of Fig. 1, and the same reference numerals are used to indicate corresponding parts.

In the embodiment of Fig. 10, the resilient spring is connected to a ring 40 which is clamped to the partition 7, and to the cup 4, by a clamping ring 41. Also, in the embodiment of Fig. 10, there is no lower snubber plate since the snubbing effect of such a plate is provided by a surface of the partition 7. The upper snubber plate 22 also extends over the convoluted passageway 9 to separate that passageway 9 from the working chamber 8. There will be an opening (not shown) in the upper snubber plate 22 to permit fluid in the working chamber 8 to

communicate with the passage 9, and hence via the opening 11 to the compensation chamber 12.

Figs. 11 and 12 show the shape of the convoluted annular diaphragm 50 in more detail. The diaphragm comprises a convoluted sheet of resilient material 42 connected to first and second anchor rings 43,44. One anchor ring 43, one the radially inner surface of the diaphragm 50 is then fixed to the partition 7, as is the radially outer anchor ring 44.

As can be seen from Figs. 11 and 12, the flexible part 42 of the diaphragm 50 is convoluted. In the arrangements shown in Figs. 10 and 11, this means that both the upper and lower surfaces 45,46 cross the line 47 joining the anchor parts 43, 44 twice. The diaphragm 50 will then have a surface area which is at least 1.1 times greater than the area defined by the annular plane between the anchor rings 43,44. The flexible part 42 should also have thickness of 1/8 or less of the distance between the anchor rings 43,44.

Fig. 10 shows that the upper snubber plate 22 and the surface of the partition 7 below the diaphragm 20 are curved so as to conform generally to the shape of the convoluted diaphragm 20. Such curved snubbing surfaces will provide the gradual snubbing of the diaphragm 20 that also occurred in the embodiments of Fig. 7.

The effect of use of such a convoluted diagram 50 is shown in Fig. 13. The mounting device has a low dynamic stiffness in a region around 150 Hz. If the present invention were not used, it would be possible to generate such a low dynamic stiffness only by lowering the mean dynamic stiffness over a wider range (e.g. by reducing the dynamic stiffness over the frequency range 50 Hz to 200 Hz. By using the present invention, however, the low dynamic stiffness (anti-resonance) at around 150 Hz is enhanced, without the mean dynamic stiffness in the 50 to 200 Hz range being reduced. Fig. 13 also shows that the use of such a convoluted diaphragm 50 may also generate a peak in the dynamic stiffness at approximately 250 Hz, but this is not usually a disadvantage.

CLAIMS

1. A hydraulically damped mounting device comprising two anchor parts connected by a deformable wall; a working chamber enclosed between the deformable wall and a partition rigidly associated with a first one of the anchor parts, the working chamber containing hydraulic fluid; a compensation chamber for the hydraulic fluid, the compensation chamber being at least partially bounded by a second deformable wall; a passage between the chambers to allow fluid communication between them; and first and second flexible diaphragm parts having different characteristics, the diaphragm part acting as a barrier between the hydraulic fluid and at least one gas chamber.

2. A hydraulically damped mounting device according to claim 1, wherein each diaphragm part acts as a barrier between the hydraulic fluid and a corresponding gas chamber.

3. A hydraulically damped mounting device according to claim 1 or claim 2, wherein the first diaphragm part extends circumferentially around the second diaphragm part.

4. A hydraulically damped mounting device according to claim 1 or claim 2, wherein the first and second diaphragm parts are integral.

5. A hydraulically damped mounting device according to any one of the preceding claims,

wherein the flexible diaphragm parts have different effective stiffnesses.

6. A hydraulically damped mounting device according to claim 5, wherein the first diaphragm part is of a first stiffness and is covered by a snubber plate with an opening or openings therein which have a first ratio of the sum of the areas of those apertures to their average length, and the second diaphragm part has a second stiffness different from the first, and is covered by a snubber plate with an opening or openings for which the ratio of the sum of the areas to the average length has a second ratio which is different from the first ratio.

7. A hydraulically damped mounting device according to claim 6, wherein the diaphragm part which has the lesser stiffness is the one for which the opening(s) in the covering snubber plate have the smaller ratio of area sum to average length.

8. A hydraulically damped mounting device according to claim 7, wherein the two diaphragm parts contact the snubbing surfaces at different points in the pressure/displacement volume characteristic of the respective diaphragm part.

9. A hydraulically damped mounting device according to claim 5, wherein one diaphragm part has a lower stiffness and a higher ratio of opening area sum to average length than the other diaphragm part.

10. A hydraulically damped mounting device according to claim 9, wherein the snubber surfaces of the two diaphragm parts are such that the diaphragm part with the lower stiffness snubs at a lower displacement volume than the other diaphragm part.

11. A hydraulically damped mounting device according to any one of the preceding claims, wherein at least one of the diaphragm parts is convoluted and has at least one correspondingly curved snubbing surface associated therewith.

12. A hydraulically damped mounting device comprising two anchor parts connected by a deformable wall; a working chamber enclosed between the deformable wall and a partition rigidly associated with a first one of the anchor parts, the working chamber containing hydraulic fluid; a compensation chamber for the hydraulic fluid, the compensation chamber being at least partially bounded by a second deformable wall; a passage between the chambers to allow fluid communication between them; and an annular flexible diaphragm acting as a barrier between the hydraulic fluid and a gas chamber, the diaphragm being convoluted.

13. A hydraulically damped mounting device according to claim 12, wherein the convolution of the diaphragm are such that one or both surfaces of the diaphragm cross the line joining the radial

edges thereof at least twice.

14. A hydraulically damped mounting device according to claim 12 or claim 13, wherein the actual surface area of the diaphragm which is contacted by hydraulic fluid exceeds the area of the annular plane defined between the radial edges of the part contacted by hydraulic fluid by a factor of at least 1.1, preferably higher.

15. A hydraulically damped mounting device according to any one of claims 12 to 14, wherein the ratio of the minimum thickness of the diaphragm to the radial width of the diaphragm is not greater than 1/8.

16. A hydraulically damped mounting device according to any one of the preceding claims, wherein the or each gas chamber has a valved bleed orifice extending therefrom.

17. A hydraulically damped mounting device according to any one of the preceding claims, wherein the deformable wall is resilient.

18. A hydraulically damped mounting device substantially as herein described with reference to and as illustrated in Figs. 1 and 2, or Figs. 3 to 5, or Figs. 6 to 8, or Fig. 9, or Fig. 10 of the accompanying drawings.

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-25 -

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Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE: EPODOC	Documents considered relevant following a search in respect of Claims :- 1-18

Categories of documents

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Category	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2165617 A (IMPERIAL CLEVITE INC) see especially Figure 1	1,5,17

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